

REMARKS

Claims 1-8 were rejected under §102 over Komai '384. This rejection is respectfully traversed. The last paragraph of claim 1, as exemplified in the drawing, sets out the Applicant's claim to *interdiffusing the copper compound [5] and the reactive layer [6] by heat treatment to thereby form an alloy layer of copper [8]*. With respect, these features are not anticipated.

(1) No interdiffusion of a Cu compound and a reactive layer is disclosed by Komai. Komai discloses that copper 21 in a trench (Fig. 1A) is immersed in an aqueous solution of a palladium salt, so that the copper at the surface is displaced by palladium. The displacement leads to a formation of a thin palladium film (catalytic metal film) 26 (Fig. 1B).

The displacement is not an interdiffusion step (and also not an alloying step). The displacement is caused by an ion exchange reaction, which Komai gives as



Komai refers to a “palladium displacement plating” process (column 4, line 29, and throughout the specification) in which “copper is displaced by palladium” (column 4, line 32).

No intermingling of copper and palladium is disclosed. This is shown not only by Komai's statement that the copper is “displaced” but also by statements that the process results in “plating” (column 4, line 29) and that a “thin palladium film” results (column 4, line 33). Komai illustrates the plated thin film 26 as a layer distinct from the adjoining copper in Figs. 1B and 1C.

(2) The Examiner is invited to consider that ion exchange is inherently a surface phenomenon, which is the reason that water softeners and related devices relying on this type of exchange are designed to provide large surface areas, for example with pellets. In a metal such as copper, ions are confined to within a very thin layer next to the surface, and therefore the

replacement of copper by palladium can also extend a very short distance into the metal if the reaction is ionic. The Examiner is invited to consider the attached page 24 from Jackson, *Classical Electrodynamics*, showing that in copper ions will exist within a band only about 4 Angstroms thick at the surface.

Since palladium is a metal and therefore a conductor, once a film of palladium is formed more than a few Angstroms thick, there will be no free charge associated with copper and the film will cease to grow in thickness. However, at lesser distances from the surface, palladium will replace any copper atoms. Thus, the palladium film will be distinct and not intermingled with the copper, as Komai itself implies. There will be no mixture and therefore no alloy.

(3) The heat treatment of the Applicant's independent claims causes mixing by diffusion (page 6, line 11). When metals are mixed by diffusion, there is no limit to how far a metal atom can penetrate into another metal. Therefore the metals become mixed and alloyed, not layered as separate metals.

Komai's displacement process takes place between 30°C and a boiling point of the plating solution (col. 3, lines 7-8), which is lower than the range disclosed by the Applicant for interdiffusion of the copper and palladium (100-350 °C, page 6, line 14). The Applicant's range is now recited in the new dependent claims.

(4) With respect, the Examiner's assertion at page 3, line 8, that Komai discloses interdiffusing by heat treatment, resulting in an alloy, is incorrect. Neither diffusion nor heat treatment is disclosed, and the word "alloy" is not seen anywhere in the reference.

(5) The Examiner asserts that Komai teaches at column 4, line 49, the nitriding, oxidizing, boronizing, sulphidizing or phosphidizing recited in claims 2 and 6. However, the reference discloses no process for obtaining copper thus, but instead discloses *replacing* copper

with other metals ("Au, Ni, Co, Pt or the like" at line 46). Moreover, the only metallic compounds listed are chlorides and sulfates (not sulphides).

(6) Regarding claims 3 and 7, only metals catalytic to copper are disclosed in the reference, and it is not established that all of the claimed metals are in that category.

(7) Regarding claims 4 and 8, no citation is presented to support the assertion that the subject matter is anticipated.

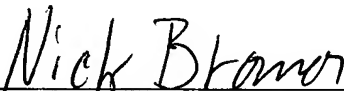
The dependent claims are all also patentable by their dependence.

Withdrawal of the rejection and allowance of the claims is requested.

Respectfully submitted,

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Date

  
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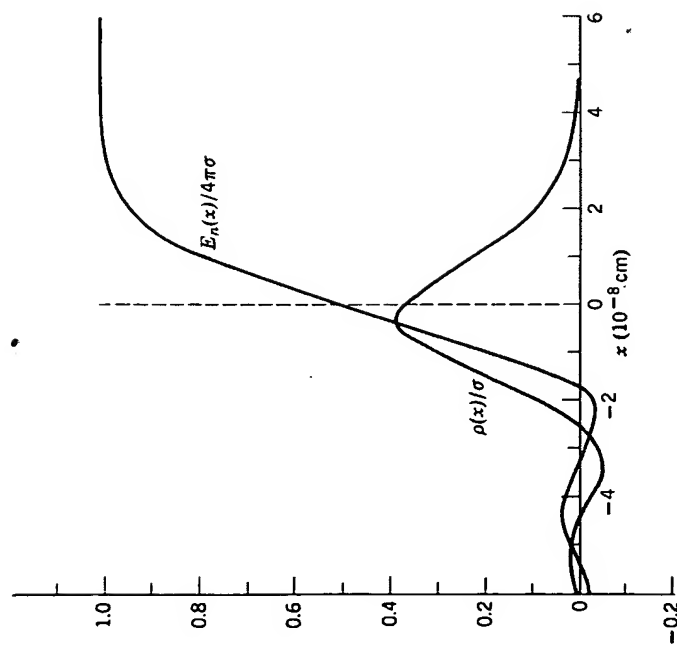


Fig. I.6 Distribution of excess charge at the surface of a conductor and of the normal component of the electric field. The ions of the solid are confined to  $x < 0$  and are approximated by a constant continuous charge distribution through which the electrons move. The bulk of the excess charge is confined to within  $\pm 2$  angstroms of the "surface."

the atomic structure of materials. Consider, for instance, the distribution of excess charge of a conducting body in electrostatics. It is well known that this charge lies entirely on the surface of a conductor. We then speak of a *surface* charge density  $\sigma$ . There is no electric field inside the conductor, but there is, in accord with (I.17), a normal component of electric field just outside the surface. At the microscopic level the charge is not exactly at the surface and the field does not change discontinuously. The most elementary considerations would indicate that the transition region is a few atomic diameters in extent. The ions in a metal can be thought of as relatively immobile and localized to 1 angstrom or better; the lighter electrons are less constrained. The results of model calculations\* are shown in Fig. I.6. They come from a solution of the quantum-mechanical many-electron problem in which the ions of the conductor are approximated by a continuous constant charge density for  $x < 0$ . The electron density ( $r_s = 5$ ) is roughly appropriate to copper and the heavier alkali metals. The excess

\* N. D. Lang and W. Kohn, *Phys. Rev.* **B1**, 4555 (1970); **B3**, 1215 (1971); V. E.

## Refs. I

## Introduction and Survey

electronic charge is seen to be confined to a region within  $\pm 2$  angstroms of the "surface" of the ionic distribution. The electric field rises smoothly over the region to its value of  $4\pi\sigma$  "outside" the conductor. For macroscopic situations where  $10^{-7}$  cm is a negligible distance, we can idealize the charge density as electric field behavior as  $\rho(x) = \sigma\delta(x)$  and  $E_n(x) = 4\pi\sigma\theta(x)$ , corresponding to truly surface density and a step-function jump of the field.

We see that the theoretical treatment of classical electromagnetism involves several idealizations, some of them technical and some physical. The subject of electrostatics, discussed in the first chapters of the book, developed as an experimental science of *macroscopic* electrical phenomena, as did virtually all other aspects of electromagnetism. The extension of these macroscopic laws even for charges and currents in vacuum, to the *microscopic* domain was for the most part an unjustified extrapolation. Earlier in this introduction we have discussed some of the limits to this extrapolation. The point to be made here is the following. With hindsight we know that many aspects of the laws of classical electromagnetism apply well into the atomic domain provided the sources are treated quantum mechanically, that the averaging of electromagnetic quantities over volumes containing large numbers of molecules so smooths the rapid fluctuations that static applied fields induce static average responses in matter that excess charge is on the surface of a conductor in a macroscopic sense. The Coulomb's and Ampère's macroscopic observations and our mathematical abstractions from them have a wider applicability than might be supposed by supercautious physicist. The absence for air of significant electric or magnetic susceptibility certainly simplified matters!

## REFERENCES AND SUGGESTED READING

The history of electricity and magnetism is in large measure the history of science itself. We have already cited

Whittaker's two volumes,

the first covering the period up to 1900, as well as the shorter account emphasizing optics in

Born and Wolf.

Another readable account, with perceptive discussion of the original experiments, N. Feather, *Electricity and Matter*, University Press, Edinburgh (1968).

The experimental tests of the inverse square nature of Coulomb's law or, in modern language, the mass of the photon, are reviewed by

I. Yu. Kobzarev and L. B. Okun', *Uspekhi Fiz. Nauk* **95**, 131 (1968) [transl., *Sov. Phys. Uspekhi* **11**, 338 (1968).]

and

A. S. Goldhaber and M. M. Nieto, *Rev. Mod. Phys.* **43**, 277 (1971).

Suggested reading on the topic of the macroscopic Maxwell equations and the derivation from the microscopic equations can be found at the end of Chapter 6. The basic physics of dielectrics, ferroelectrics, and magnetic materials can be found

# **Classical Electrodynamics**

**Second Edition**

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